
APPENDIX C

Description of the Habitat-based Bird Model

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APPENDIX C

DESCRIPTION OF THE HABITAT-BASED BIRD MODEL

This appendix provides a description of the methods used to develop habitat-based models for waterbird focal species density, and predictions of bird numbers under the alternatives considered in the Draft Programmatic Environmental Impact Report (PEIR). The model-building and prediction process can be summarized as follows:

- **Identification of focal species** for assessing the effects of each alternative, based on specific biological criteria;
- **Development of species-specific statistical models** for habitats with adequate data from the 1999 comprehensive Salton Sea bird survey (Warnock et al., 2004) and quantifiable variability among survey areas;
- **Calculation of species-specific mean densities** for habitats lacking adequate data from the 1999 comprehensive Salton Sea bird survey and/or quantifiable variability among survey areas;
- **Development of species-specific statistical models** for Saline Habitat Complex, based on waterbird data from the South San Francisco Bay (Warnock et al., 2002; Stralberg et al., 2003; Takekawa et al., 2005);
- **GIS-based delineation of habitat units** (polygons) for each proposed alternative, and calculation of habitat and landscape variables for each habitat unit;
- **Evaluation of GIS-based habitat alternatives** and prediction of waterbird numbers using Point Reyes Bird Observatory (PRBO) Habitat Conversion Model (HCM) tool for ArcGIS software; and
- **Adjustment of San Francisco Bay-based prediction** using a Salton Sea – San Francisco Bay conversion factor.

IDENTIFICATION OF FOCAL SPECIES

From the waterbird species known to be present at the Salton Sea in 1999, a shorter list of species that are thought to depend on the Salton Sea for at least part of the year (breeding, migration, or winter), and with sufficient data for analysis was developed. The list of focal species and criteria is presented in Table C-1.

Table C-1
Focal Bird Species and Criteria

Species	Criteria
Aechmophorus spp. (Includes Clark's and Western Grebes)	Greater than 10,000 birds counted on single survey (Shuford et al., 2002)
American Avocet	Greater than 10,000 birds counted on single survey (Shuford et al., 2002)
American White Pelican	DFG Bird Species of Special Concern Greater than 10,000 birds counted on single survey (Shuford et al., 2002)

Table C-1
Focal Bird Species and Criteria

Species	Criteria
Black Skimmer	DFG Bird Species of Special Concern Service Birds of Conservation Concern - BCR 33 National Waterbird Conservation Plan (species considered Highly Imperiled or of High Concern)
Black Tern	DFG Bird Species of Special Concern
Black-necked Stilt	Greater than 10,000 birds counted on single survey (Shuford et al., 2002)
Brown Pelican	Federally endangered species State endangered species
California Gull	Greater than 10,000 birds counted on single survey (Shuford et al., 2002)
Cattle Egret	Greater than 10,000 birds counted on single survey (Shuford et al., 2002)
Double-crested Cormorant	DFG Bird Species of Special Concern Greater than 10,000 birds counted on single survey (Shuford et al., 2002)
Dowitcher spp (Includes Long-billed and Short-billed Dowitchers)	Greater than 10,000 birds counted on single survey (Shuford et al., 2002)
Dunlin	U.S. Shorebird Conservation Plan species or subspecies (4-5 priority score)
Eared Grebe	Greater than 10,000 birds counted on single survey (Shuford et al., 2002)
Gull-billed Tern	DFG Bird Species of Special Concern National Waterbird Conservation Plan (species considered Highly Imperiled or of High Concern) Service Birds of Conservation Concern - BCR 33
Least Bittern	DFG Bird Species of Special Concern
Long-billed Curlew	DFG Bird Species of Special Concern U.S. Shorebird Conservation Plan species or subspecies (4-5 priority score)
Marbled Godwit	U.S. Shorebird Conservation Plan species or subspecies (4-5 priority score) Service Birds of Conservation Concern - BCR 33
Ring-billed Gull	Greater than 10,000 birds counted on single survey (Shuford et al., 2002)
Ruddy Duck	Greater than 10,000 birds counted on single survey (Shuford et al., 2002)
Snowy Egret	National Waterbird Conservation Plan (species considered Highly Imperiled or of High Concern)

Table C-1
Focal Bird Species and Criteria

Species	Criteria
Snowy Plover	DFG Bird Species of Special Concern U.S. Shorebird Conservation Plan species or subspecies (4-5 priority score) Service Birds of Conservation Concern - BCR 33
Western Sandpiper	Greater than 10,000 birds counted on single survey (Shuford et al., 2002) U.S. Shorebird Conservation Plan species or subspecies (4-5 priority score)
Whimbrel	U.S. Shorebird Conservation Plan species or subspecies (4-5 priority score) Service Birds of Conservation Concern - BCR 33
White-faced Ibis	DFG Bird Species of Special Concern Greater than 10,000 birds counted on single survey (Shuford et al., 2002)

Notes:

DFG = Department of Fish and Game

Service = U.S. Department of the Interior, Fish and Wildlife Service

DEVELOPMENT OF SALTON SEA STATISTICAL MODELS

To estimate shoreline habitat bird densities, data from the 1999 comprehensive shoreline survey (Warnock et al., 2004) was used. These surveys were designed to cover the range of seasons in which waterbirds occupy the Sea, represented complete spatial coverage of the Salton Sea, and were partitioned by enough subareas to allow for analysis of landscape and habitat variation.

Shoreline surveys were conducted by segment, as delineated by Warnock et al. (2004), and buffered by 500 meters into the Salton Sea to represent the actual area surveyed. Densities for each segment were calculated based on dividing the number of birds counted in a particular survey by the area (hectares) of the segment.

A number of bathymetric and landscape variables were calculated for each segment, based on *a priori* hypotheses about the factors influencing each focal species. A list of preliminary variables examined (by species group) is presented in Table C-2.

Based on correlation matrices for the above-listed variables, variables that were highly correlated with other variables and that were thought to have more important biological significance (e.g., mean slope, mean depth, and percent shallow area) were not considered separately. From the remaining candidate variables, all possible linear regression models (i.e., all possible combinations of variables) were constructed to predict the log-transformed density of each focal species. This was automated using a program written for SAS by Mark Herzog of PRBO. Variables were eliminated if the variable provided little or no contribution to the models (except for bathymetric variables), as well as variables with relationships that changed direction in the presence of other variables, suggesting that they were surrogates for other factors. This is a conservative approach to model selection due to the prediction purpose for which the models were used.

Table C-2
Variables Used for Development of Statistical Models

Variables	Species Group						
	Shorebirds	Fish-eating Divers	Invertebrate-eating Divers	Pelicans & Cormorants	Waders	Terns	Gulls
Sediment							
Mean percent sand	X		X				
Bathymetry							
Mean depth	X	X	X	X	X	X	X
Mean slope	X	X	X	X	X	X	X
Percent shallow (Less than 3 feet)	X	X	X	X	X	X	X
Surrounding land use (5-kilometer radius)							
Percent cropland	X				X	X	
Surrounding wetlands (5-kilometer radius)							
Percent <i>Typha latifolia</i>			X		X		
Percent <i>Tamarix ramosissima</i>					X		
Percent shoreline strand	X					X	X
Percent adjacent wetland	X	X	X	X	X	X	X
Percent managed wetland	X	X	X	X	X	X	X
Percent riparian				X	X		
Percent fish farms and hatcheries		X		X	X	X	X
Shoreline characteristics							
Distance to nearest river	X	X	X	X	X	X	X
Shoreline fractal dimension	X			X	X		X

After re-running all possible models with the new list of candidate variables, each model was assigned a weight based on the Akaike Information Criterion (AIC), which is measure of model fit that is penalized for each additional variable, to yield higher scores for more parsimonious (i.e., trading off complexity and model fit) models (Burnham and Anderson, 2003). For each focal species, the entire suite of models was used to predict (log-transformed) density within shoreline segments of the alternatives. The list of variables used in the final models for each focal species is presented in Table C-3.

Table C-3
Variables Used in the Final Models for Each Focal Species

		Variable						
Species	Species Group	Percent Shallow (Less than 3 feet)	Percent Managed Wetland	Percent Adjacent Wetland	Percent Fish Farms	Percent Riparian	Percent Cropland	Mean Percent Sand
Aechmophorus spp. ^a	Fish-eating divers	X						
American Avocet	Large shorebirds	X	X				X	
American White Pelican	Pelicans & cormorants	X	X					
Black Skimmer	Terns	X			X			
Black Tern	Terns	X	X				X	
Black-necked Stilt	Large shorebirds	X	X					
Brown Pelican	Pelicans & cormorants	X						
California Gull	Gulls	X	X	X				
Cattle Egret	Waders	X	X	X			X	
Double-crested Cormorant	Pelicans & cormorants	X			X	X		
Dowitcher spp. ^b	Small shorebirds	X	X				X	
Dunlin	Small shorebirds	X	X				X	
Eared Grebe	Invert-eating divers	X						
Gull-billed Tern	Terns	X					X	
Least Bittern	Waders	X						
Long-billed Curlew	Large shorebirds	X	X				X	
Marbled Godwit	Large shorebirds	X	X				X	X
Ring-billed Gull	Gulls	X		X				
Ruddy Duck	Invert-eating divers	X						
Snowy Egret	Waders	X	X	X	X			
Snowy Plover	Small shorebirds	X	X				X	X
Western Sandpiper	Small shorebirds	X	X				X	
Whimbrel	Large shorebirds	X						
White-faced Ibis	Waders	X	X	X			X	

^a Includes Clark's and Western Grebes.

^b Includes Long-billed and Short-billed Dowitchers.

CALCULATION OF SPECIES-SPECIFIC MEAN DENSITIES

For other Salton Sea habitats, where there was not sufficient evidence of quantifiable variability across survey areas, overall mean densities for each species-season combination were obtained. Open water (pelagic) densities were based on aerial surveys from winter 1999 (Shuford et al., 2000). These densities were applied to areas more than 500 meters away from the shoreline in the alternatives. Freshwater reservoir / lake densities were estimated from mean 1999 densities at Finney and Ramer Lakes, which represented the closest possible freshwater habitat at the Salton Sea. Managed marsh and agricultural field densities were not used in this analysis, as they were assumed to remain constant for all alternatives.

DEVELOPMENT OF SPECIES-SPECIFIC STATISTICAL MODELS FOR PROPOSED SALINE HABITAT COMPLEX

Because most of the alternatives involve higher salinity habitats than have been surveyed at the Salton Sea, data from San Francisco Bay salt ponds were used to estimate bird densities for all shallow habitats with salinities above 40,000 mg/L (i.e., high salinity sea shorelines). A combined dataset from PRBO and U.S. Department of the Interior, Geological Survey (USGS) surveys from 1999 to 2001 (Warnock et al., 2002; Stralberg et al., 2003) and from 2002 to 2004 (Takekawa et al., 2006) was used. Only surveys with both salinity and bathymetric information were included.

Saline Habitat Complex pond types were defined by parameters in the above-mentioned datasets and summarized in Table C-4. Using Saline Habitat Complex pond type as a categorical variable, a single linear regression model that provided the best fit to the data for each focal species-season combination was developed.

Table C-4
Parameters Used to Define Different Saline Habitat Complex Cell Types

Microhabitat Code	Description	Depth	Salinity
LS1	Low salinity, shallow	(At least 10 percent less than 15 centimeters deep AND not more than 10 percent greater than 1 meter deep) OR (mean depth less than 0.5 meter)	20,000 to 60,000 mg/L
LS2	Low salinity, intermediate	In between LS1 and LS3	20,000 to 60,000 mg/L
LS3	Low salinity, deep	At least 50 percent greater than 1 meter deep AND no more than 10 percent less than 15 centimeters deep	20,000 to 60,000 mg/L
HS1	High salinity, shallow	(at least 10 percent less than 15 centimeters deep AND not more than 10 percent greater than 1 meter deep) OR (mean depth less than 0.5 meter)	60,000 to 150,000 mg/L
HS2	High salinity, intermediate	In between HS1 and HS3	60,000 to 150,000 mg/L
HS3	High salinity, deep	At least 50 percent greater than 1 meter deep AND no more than 10 percent less than 15 centimeters deep	60,000 to 150,000 mg/L
IS	Hypersaline	Any	150,000 to 200,000 mg/L
BS	Brine sink	Any	200,000 to 300,000 mg/L

GIS-BASED DELINEATION OF HABITAT UNITS

For each habitat alternative, the spatial units provided in shapefiles for each alternative were used to calculate the area of available habitat. For shoreline habitat, the shoreline was buffered by 500 meters into the Salton Sea to delineate the shoreline zone. This shoreline zone was then segmented into sections approximating those used for the 1999 survey (Shuford et al., 2000). Separate density estimates were obtained for each individual shoreline segment. The remaining portion of the Marine Sea (beyond 500 meters) was considered open water habitat. Each habitat unit (polygon) was attributed with the appropriate data fields needed for prediction, as summarized in Table C-5.

Table C-5
Definitions of Habitat Unit Attributes

Habitat (Code)	Fields	Definitions
Shoreline (SS)	SHArea	Area (hectares)
	Logcrop	Log (cropland proportion within 5-kilometer radius)
	Logmanwet	Log (managed wetland proportion within 5-kilometer radius)
	Logadjwet	Log (adjacent wetland proportion within 5-kilometer radius)
	Logfish	Log (fish farm proportion within 5-kilometer radius)
	Logrip	Log (riparian proportion within 5-kilometer radius)
	Meansand	Mean percent sand
	Shallowprop	Shallow (less than 3 feet) proportion
	OWArea	Area (hectares)
	Saline Habitat Complex (SH)	Area (hectares)
Open Water (OW)	LS1Area	Area of LS1 habitat (hectares)
	LS2Area	Area of LS2 habitat(hectares)
	LS3Area	Area of LS3 habitat (hectares)
	HS1Area	Area of HS1 habitat (hectares)
	HS2Area	Area of HS2 habitat (hectares)
	HS3Area	Area of HS3 habitat (hectares)
	ISArea	Area of IS habitat (hectares)
	BSArea	Area of BS habitat (hectares)
	FRArea	Area of FR habitat (hectares)
Freshwater Reservoir (FR)		

USE OF GIS-BASED INFORMATION FOR THE ALTERNATIVES

For each alternative, represented by a single shapefile with attributes as described above, densities and total numbers of each focal species by season were predicted using the PRBO HCM, a VBA template for ArcGIS coded by Sam Valdez of PRBO. The program calculates density predictions for a suite of linear models (as described above) and generates mean and standard error values for each habitat unit (polygon).

APPLICATION OF SALTON SEA – SAN FRANCISCO BAY CONVERSION FACTOR

Due to natural differences in the geography and phenology of waterbird use across San Francisco Bay and the Salton Sea, a conversion factor to obtain more appropriate predictions was developed. Because the Saline Habitat Complex or shoreline habitat component of each alternative was constructed to resemble

the current Salton Sea shoreline, it was assumed that bird densities in low salinity Saline Habitat Complex or shoreline habitats would be equivalent to predicted Salton Sea shoreline densities, assuming depth conditions are similar. Therefore, the conversion factor was based on the ratio of Salton Sea shoreline densities to San Francisco Bay low salinity (less than 45,000 mg/L) pond densities (by species and season). Species not occurring in San Francisco Bay were excluded from the analysis, and if a species did not occur in low salinity salt ponds during a particular season, the conversion factor was set to one. Predicted Saline Habitat Complex or shoreline habitat numbers were multiplied by the conversion factor after being aggregated by habitat. Conversion factors are summarized in Table C-6.

Results were evaluated using an Access database to summarize overall predictions by microhabitat (see Table C-4) and habitat (see Table C-5) to predict the habitat capacity for each species. The seasonal habitat capacity for each species under each alternative is summarized in Table C-7.

Table C-6
Conversion Factors for Saline Habitat Complex and Shoreline Habitats

Species	Season	Salton Sea Density (birds/hectare)	San Francisco Bay Density (birds/hectare)	Conversion Factor
Aechmophorus spp. ^a	Spring	0.65	0.04	17.29
Aechmophorus spp. ^a	Winter	0.23	0.02	14.38
American Avocet	Fall	0.41	0.74	0.56
American Avocet	Spring	0.42	0.65	0.65
American Avocet	Winter	0.53	0.98	0.54
American White Pelican	Fall	0.11	0.54	0.21
American White Pelican	Spring	0.50	0.05	10.78
American White Pelican	Winter	1.93	0.11	16.88
Black-necked Stilt	Fall	0.83	0.40	2.07
Black-necked Stilt	Spring	0.26	0.01	40.60
Black-necked Stilt	Winter	0.34	0.08	4.27
Brown Pelican	Fall	0.35	0.00	1.00
Brown Pelican	Winter	0.01	0.00	1.48
California Gull	Fall	0.38	0.50	0.76
California Gull	Spring	0.14	0.27	0.52
California Gull	Winter	0.27	0.17	1.57
Double-crested Cormorant	Fall	0.22	0.12	1.89
Double-crested Cormorant	Spring	0.51	0.02	28.04
Double-crested Cormorant	Winter	1.06	0.12	8.96
Dowitcher spp. ^b	Fall	0.27	0.23	1.20
Dowitcher spp. ^b	Spring	0.30	0.08	3.96
Dowitcher spp. ^b	Winter	0.24	0.51	0.46
Dunlin	Winter	0.06	1.53	0.04
Eared Grebe	Spring	4.18	0.03	142.03
Eared Grebe	Winter	15.75	0.18	87.72
Long-billed Curlew	Fall	0.02	0.00	4.27
Long-billed Curlew	Spring	0.00	0.00	1.00
Long-billed Curlew	Winter	0.03	0.07	0.39
Marbled Godwit	Fall	0.06	0.13	0.47
Marbled Godwit	Spring	0.05	0.01	4.04
Marbled Godwit	Winter	0.07	0.27	0.28

Table C-6
Conversion Factors for Saline Habitat Complex and Shoreline Habitats

Species	Season	Salton Sea Density (birds/hectare)	San Francisco Bay Density (birds/hectare)	Conversion Factor
Ring-billed Gull	Fall	0.24	0.00	77.48
Ring-billed Gull	Spring	0.24	0.01	18.29
Ring-billed Gull	Winter	1.33	0.10	13.04
Ruddy Duck	Spring	0.16	2.18	0.07
Ruddy Duck	Winter	2.07	2.49	0.83
Snowy Egret	Fall	0.12	0.10	1.17
Snowy Egret	Spring	0.01	0.02	0.59
Snowy Egret	Winter	0.03	0.10	0.28
Snowy Plover	Fall	0.03	0.00	1.00
Snowy Plover	Spring	0.03	0.04	0.68
Snowy Plover	Winter	0.02	0.05	0.35
Western Sandpiper	Fall	0.81	0.55	1.46
Western Sandpiper	Spring	0.56	0.89	0.63
Western Sandpiper	Winter	0.29	1.20	0.24

^a Includes Clark's and Western Grebes.

^b Includes Long-billed and Short-billed Dowitchers

Table C-7
Habitat Capacity as Potential Number of Birds in 2078

Season	Species	Existing Conditions	No Action Alternative - CEQA Conditions	No Action Alternative - Variability Conditions ^a	Alternatives							
					1	2	3	4	5	6	7	8
W	Aechmophorus spp. ^b	5,844	569	0	13,420	34,914	3,297	4,678	17,610	14,987	3,462	8,836
W	American avocet	5,974	1,386	0	3,747	9,920	7,477	13,420	6,407	4,275	3,841	3,253
W	American white pelican	22,283	1,004	0	12,627	27,714	23,402	26,229	20,483	19,379	14,399	16,276
W	Black-necked stilt	3,653	15,780	0	18,277	44,976	4,148	47,356	22,834	15,464	11,651	9,162
W	Double-crested cormorant	11,398	427	0	13,489	32,255	12,738	14,037	18,967	17,180	8,587	11,905
W	Dowitcher spp. ^c	2,695	221	0	1,146	4,156	2,934	4,333	2,743	1,390	1,603	670
W	Dunlin	692	492	0	888	2,165	785	2,184	1,252	954	726	667
W	Eared grebe	246,591	1,091,254	0	832,831	1,991,619	196,077	3,162,587	1,064,195	767,177	485,611	459,399
W	Long-billed curlew	313	130	0	315	713	534	1,256	380	263	321	240
W	Marbled godwit	929	487	0	945	2,223	1,211	2,706	1,369	1,015	837	775
W	Ruddy duck	25,878	1,407	0	14,588	33,103	22,800	22,059	24,988	23,864	14,922	19,095
W	Snowy egret	283	10	0	185	426	269	269	289	269	494	206
W	Snowy plover	201	21	0	106	230	257	411	147	130	144	126
W	Western sandpiper	3,254	2,532	0	3,928	10,743	3,638	11,370	6,086	3,809	2,981	2,222
W	Ring-billed gull	14,197	13,305	0	20,961	51,015	16,122	52,237	28,813	24,050	17,476	16,403
W	Brown pelican	97	0	0	125	317	72	60	177	156	50	103
W	California gull	2,857	1,387	0	2,579	6,660	4,628	7,464	4,914	4,275	5,278	2,650
S	Aechmophorus spp. ^b	6,677	556	0	5,717	13,566	5,354	3,092	9,589	9,510	4,038	6,554
S	American avocet	4,605	2,087	0	4,315	9,902	6,116	14,079	5,849	4,609	4,228	3,793
S	American white pelican	5,335	0	0	1,085	2,277	5,725	5,347	2,853	2,618	2,256	2,768
S	Black-necked stilt	2,821	18,443	0	19,220	47,350	3,360	54,158	23,712	15,793	11,920	9,091
S	Double-crested cormorant	5,499	1,424	0	7,504	18,404	5,770	9,369	10,700	9,495	6,108	5,702
S	Dowitcher spp. ^c	3,296	12,551	0	18,441	46,230	3,670	38,115	23,375	16,565	11,366	9,068

Table C-7
Habitat Capacity as Potential Number of Birds in 2078

Season	Species	Existing Conditions	No Action Alternative - CEQA Conditions	No Action Alternative - Variability Conditions ^a	Alternatives							
					1	2	3	4	5	6	7	8
S	Eared grebe	44,034	1,823,745	0	1,079,054	2,564,956	43,665	5,010,747	1,311,514	842,053	625,637	454,996
S	Marbled godwit	643	26	0	390	856	960	1,484	540	419	479	403
S	Ruddy duck	1,699	310	0	1,292	2,854	1,908	2,771	1,953	1,750	1,307	1,399
S	Snowy egret	107	36	0	116	329	159	233	211	176	123	83
S	Snowy plover	298	64	0	180	409	324	486	291	256	201	219
S	Western sandpiper	6,097	8,908	0	16,682	41,921	6,863	31,880	22,156	16,387	11,187	9,428
S	Ring-billed gull	2,592	1,939	0	3,888	9,664	3,640	8,874	5,703	5,083	2,993	3,152
S	California gull	1,488	719	0	1,498	3,739	2,108	3,970	2,431	2,161	1,311	1,429
F	American avocet	4,611	2,067	0	5,451	14,847	4,761	10,324	8,846	6,270	3,913	3,475
F	American white pelican	1,302	54	0	407	1,739	1,354	1,646	1,289	564	376	198
F	Black-necked stilt	9,118	5,367	0	13,828	33,433	12,031	31,358	18,230	14,339	11,714	9,818
F	Double-crested cormorant	2,486	407	0	3,263	8,200	2,665	4,086	4,706	4,079	2,430	2,170
F	Dowitcher spp. ^c	3,059	147	0	6,759	17,961	3,289	4,175	9,511	7,759	4,198	4,011
F	Long-billed curlew	267	3,075	0	2,735	6,422	413	8,797	3,337	2,377	1,510	1,351
F	Marbled godwit	726	285	0	1,478	3,796	1,023	2,385	1,958	1,474	944	832
F	Snowy egret	1,290	109	0	1,242	2,853	1,117	2,111	1,446	1,190	2,541	922
F	Snowy plover	339	37	0	339	986	327	427	583	425	255	212
F	Western sandpiper	9,049	11,207	0	52,064	131,878	10,019	41,638	66,476	55,178	31,372	28,286
F	Ring-billed gull	2,588	9,968	0	38,658	95,953	4,229	31,469	47,793	41,267	23,374	20,807
F	Brown pelican	3,721	108	0	1,165	2,339	4,360	4,938	2,187	2,030	1,831	2,190
F	California gull	4,025	3,984	0	10,623	26,663	5,563	15,553	14,729	12,401	5,636	7,079

^a Assumes that the Salton Sea would not support suitable habitat for birds in 2078 under the No Action Alternative-Variability Conditions because of salinity would exceed 200,000 mg/L.

^b Includes Clark's and western grebes.

^c Includes long-billed and short-billed dowitchers.

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